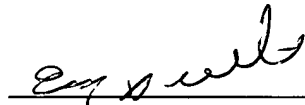


## REMARKS

The changes are shown with strikethrough for deleted matter and underlining for added matter. No new matter has been added as a result of this amendment.

Applicants respectfully submit that all of the pending claims are in condition for allowance and seek an early allowance thereof. If for any reason the Examiner is unable to allow the application in the next Office Action and believes that a telephone interview would be helpful to resolve any remaining issues, he is respectfully requested to contact the undersigned attorney or agent.

Respectfully submitted,



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Craig A. Summerfield  
Registration No. 37,947  
Attorney for Applicants

BRINKS HOFER GILSON & LIONE  
P.O. BOX 10395  
CHICAGO, ILLINOIS 60610  
(312) 321-4200

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## POSITIONING DEVICE FOR AN X-RAY DETECTOR

### RELATED APPLICATIONS

#### BACKGROUND

#### FIELD

[0001] ~~The invention relates to a~~ positioning device for an X-ray detector and an X-ray source is provided.

#### RELATED ART

[0002] X-ray machines serve to take X-ray images, by means of an X-ray detector and an X-ray source. They are used for instance in medical diagnosis, ~~where~~ In the medical field, bodies or body parts of patients are X-rayed in various positions and from various directions for diagnosis purposes. ~~For positioning the patient, among other possibilities p~~ Patient-supporting tables are used, ~~on which so~~ the patient or body part can lie or sit ~~or can place the body part to~~ while being examined.

[0003] In X-ray machines with patient-supporting tables, the X-ray detector is usually located under the tabletop ~~itself,~~ while an X-ray source X-rays the patient from above. A corresponding arrangement of X-ray sources and an X-ray detector can be achieved by using a so-called C-arm, for instance, which carries the sources and detector ~~them on its~~ diametrically opposed ends. This arrangement ~~It~~ can also be achieved by means of a separate disposition of the X-ray detector in the patient-supporting table and of the X-ray source on a free-standing tripod or a tripod secured to the ceiling of the room.

[0004] To make different radiology directions possible, the X-ray source may be movably supported on a tripod in all directions in space, However, ~~while~~ on a C-arm, ~~it the X-ray source is fixedly located and~~ is movable solely by moving the

C-arm itself. ~~The X-ray detector, conversely, is located on a C-arm and is, automatically always diametrically opposite the X-ray source. Thus, the X-ray detector while it is movable only to a limited extent as the patient-supporting device is being moved toward the X-ray detector.~~

5     **[0005]**     Depending on where the X-ray machine is used, the freest possible adjustability of the radioscopy direction may be desired, for instance in radiation monitoring of interventional procedures in surgery or interventional cardiology. The radioscopy direction must be adjustable such that the various surgical steps are made optimally visible in the X-ray projection. At the same time, precisely in  
10     ~~interventional use, the freest possible accessibility of the patient-supporting table and the patient lying on the table~~ it is of particular significance. C-arm X-ray machines are therefore often used in interventional use. While C-arm X-ray machines ~~are extremely flexibly positionable (capable of various positions) and have advantages because of the particularly flexible (capable of various positions)~~  
15     ~~capabilities of orientation, at the same time because of the orientation, the C-arm they is~~ are relatively bulky and hinders access to the patient ~~to a not inconsiderable extent. The size and arrangement of the C-arm~~ limits the possibilities for using C-arm equipment.

20     **[0006]**     From European Patent Disclosure EP 1 129 664, a patient-  
~~supportingsupport~~ table with a flexibly positionable X-ray detector is known. The X-ray detector is ~~supported~~ longitudinally displaceable under the tabletop of the device. ~~The X-ray detector~~ It is also pivotable out of the device transversely to the longitudinal direction and can be tilted ~~there-in~~ such a way that X-ray detector it is oriented perpendicular to the tabletop. When this patient-~~supportingsupport~~  
25     ~~supportingsupport~~ device is used in combination with an X-ray source that is ~~freely-movable~~ in all directions ~~in space~~, various radioscopy directions can be flexibly set (adjusted), and the accessibility of a patient lying on the tabletop is not restricted by a C-arm. However, the variation of the radioscopy directions is not continuously adjustable in the same way as with a C-arm machine. Thus, A surgeon must therefore

accustom himself to the handling of the device and the X-ray images that can be made using the device.

## SUMMARY

5        **[0007]**    ~~The object of the invention is to disclose a~~ A positioning device for an  
X-ray detector which simultaneously assures as flexible (various positions) as  
~~possible a continuous adjustment of the radioscopy direction and the freest~~  
~~possible~~ easy accessibility to a patient to be examined on the patient-support table is  
provided. An X-ray machine has such a positioning device.

10        ~~**[0008]**    The invention attains this object by means of a device having the~~  
~~characteristics of the independent claim.~~

15        **[0008]**    ~~It is a fundamental concept of the invention to disclose a~~ A patient  
supporting device, with a positioning device located under the patient supporting  
device, for an X-ray detector or an X-ray source that has an arched arm, in which  
the X-ray detector or X-ray source is supported displaceably in the direction  
20        of the arch, and that has a base in which with an the arched arm is supported  
displaceably in the direction of the arch. The use of an arched arm enables the  
flexible adjustability (capable of) various positions) of the radioscopy direction in  
the same way as would be done with a C-arm. For the surgeon, this has the  
advantage that he can use continuously adjustable the radii of motion and  
25        radioscopy angles in the way that is familiar and customary to him.

**[0009]**    The movability of the X-ray detector or the X-ray source on the arched  
arm, however, simultaneously increases its range of motion in comparison with a  
C-arm, on which the X-ray detector and the X-ray source are secured  
nondisplaceably. As a result, to make a comparable range of motion possible, the  
30        arm can be reduced to half the length, compared to a C-arm arm. This reduces its  
bulk, and there is less hindrance to access to the patient-supporting support device.  
~~Last but not least, the~~ The displaceability on a circular path, in cooperation  
combination with an X-ray source or X-ray detector located separately from the  
positioning device and displaceable on a contrarily extending circular path, makes

it possible to create images of slices or three-dimensional images of the body to be examined. Such images of the body have generally been made ~~until now under comparable conditions~~ using C-arm X-ray machines, whose image data is ~~are~~ processed into three-dimensional images by analogy with computed tomography image data. The prerequisite for this is the motion along a circular path whose center point is located in the body region to be examined.

[0010] In an advantageous feature ~~of the invention~~, the arched arm is supported displaceably in the direction of the arch ~~on~~ in a second arched arm, and the second arched arm is supported in the base displaceably in the direction of the arch. By ~~the use of~~ using a second displaceable arm, the range of motion of the X-ray detector can be doubled, without having to increase the length of each individual arched arm substantially. Thus, a greater range of motion is attained while the bulk of the positioning device remains the same, and the accessibility to the patient-~~supporting~~ support device is not additionally hindered.

[0011] In a further advantageous feature ~~of the invention~~, the X-ray detector or the X-ray source can be supported movably in the arched arm in the radial direction relative to the arch. As a result, the X-ray detector or the X-ray source can, as needed, be brought closer to a patient positioned in the center of the arch. This is especially advantageous if the positioning device is located under the patient-~~supporting~~ ing table. If an X-ray detector is supported in the positioning device, ~~the X-ray detector~~ it can be brought from below, toward the patient-~~supporting~~ ing table, so that an X-ray can be made with a vertical angle of incidence of the X-radiation. In this arrangement, X-ray images can be made ~~of the kind that~~ are possible with conventional X-ray machines ~~with that have~~ an X-ray detector under the table, known as a Bucky systems. This expands the possibilities for using the X-ray machine.

[0012] In a further advantageous feature ~~of the invention~~, the positioning device is used in an X-ray machine with a patient-~~supporting~~ ing device, and the X-ray machine has an X-ray source that is movably supported in all directions ~~in space~~ and is located separately from the positioning device. This configuration, because

of the separate disposition of the X-ray source, ~~makes especially~~ allows free accessibility to the patient-supporting table ~~possible, since because~~ the positioning device does not substantially restrict accessibility, ~~and regardless of this the~~ In addition, the X-ray source can be positioned ~~so as to~~ present as little hindrance as possible. ~~At the same time, b~~ Because of the free movability of the X-ray source, arbitrary angles of incidence can be set (adjusted). The X-ray source can for instance be supported from a ceiling-mounted tripod, ~~where essentially only from above can it restrict~~ that allows increased accessibility to the patient-supporting table.

[0013] In a further advantageous feature ~~of the invention,~~ the X-ray machine has a control unit, ~~which~~ that is connected to the X-ray source and the positioning device. The control ~~and is embodied so as to~~ unit moves the X-ray source and the positioning device ~~in a manner adapted to one another~~ together, so that they assume a predetermined orientation ~~to one another~~ relative to each other. The predetermined orientation ~~to one another~~ can be selected such that the X-ray detector is at all times located in the X-ray beam of the X-ray source and perpendicular to the X-ray beam ~~it~~. This orientation makes it possible to create an X-ray image at all times, without a machine operator having to manually adjust the various individual positions of each device exactly. ~~Instead~~ For example, it suffices if the X-ray source is aimed by a machine operator in a desired way, ~~for instance,~~ while the X-ray detector is made to automatically follow its the motion using the ~~by means of the control unit. Maintaining the orientation by means of the~~ The control unit can also be used to make three-dimensional or slice images of the body to be examined, ~~in which~~ where the X-ray source and the X-ray detector must be moved along a circular path, diametrically opposite one another.

## DRAWINGS

[0014] ~~Further advantageous features of the invention will become apparent from the dependent claims.~~

Exemplary embodiments of the invention are described in further detail below in conjunction with drawings. Shown in the drawings are:

[0015] Fig. 1, a positioning device with an X-ray detector and a patient-supporting device;

[0016] Fig. 2, the positioning device in a different position of the X-ray detector;

[0017] Fig. 3, an X-ray machine with a positioning device; and

[0018] Fig. 4, an X-ray machine with a positioning device and a control unit.

## DESCRIPTION

[0019] In Fig. 1, one embodiment of the positioning device 1 is shown along with a patient-supporting device. The patient-supporting device comprises a patient-supporting table 5, which is secured to a table pedestal 7.

[0020] The positioning device 1 is located under the patient-supporting support table 5. It has a base 9, ~~by means of which it that~~ is supported either on the patient-supporting support device or on the floor.

[0021] An arched arm 15 is supported in the base 9 via a second arched arm 13. An X-ray detector 11 is supported on the arm 15 by ~~means of a mounting device 17.~~

[0022] The mounting device 17 is movably supported in the arm 15 such that the X-ray detector 11 is displaceable along the arm 15 in the direction of the arch.

In Fig. 1, the X-ray detector 11 is located extended in the drawing in a position in which, compared to its outset position, it is deflected maximally  
ecounterclockwise, compared to the outset position. From ~~there that~~ position, the X-ray detector 11 ~~it~~ can now be displaced ~~only~~ clockwise, which is represented in the drawing by an arrow pointing clockwise. In this direction, it can be displaced as far as the diametrically opposed maximally deflected position, without being hindered by other device elements, such as an X-ray source, since it is the only part of the device that is supported on the arm 15.

[0023] The arched arm 15 is supported ~~by~~ the second arched arm 13 and is  
displaceable in the direction of the arch. The arched arm 15 is likewise located  
in a position that is maximally deflected counterclockwise. The arm 15 can  
likewise be displaced ~~from there only~~ in the clockwise direction, which is  
5 represented by a corresponding arrow in the drawing.

[0024] The second arched arm 13 is ~~in turn~~ supported in the base 9 and is  
displaceable in the direction of the arch. However, in contrast to the X-ray  
detector 11 and the arm 15, the second arched arm 13 is not located in a  
maximally deflected position and is therefore displaceable both clockwise and  
10 counterclockwise, which is also represented by corresponding arrows in the  
drawing.

[0025] ~~In a first embodiment, the deflection of the X-ray detector 11, which~~  
~~that is supported in the positioning device 1, can be adjusted, in a first~~  
~~embodiment, by manual displacement operated done by a machine operator.~~  
15 Bearing and locking mechanisms, not shown in the drawing, assure the free  
movability and fixability in the desired deflection. In a ~~further another~~  
embodiment, the deflection of the X-ray detector 11 can be motor-adjusted by  
~~means of the positioning device 1. In this embodiment, drive motors, (not shown),~~  
automatically displace the arms 13, 15 and the mounting device 17 outward.

[0026] ~~In~~ As shown in Fig. 2, the same positioning device 1 with a patient-  
supporting support device 5 as in the preceding drawing is shown, and the same  
reference numerals as in the preceding drawing are used. However, the arched  
arms 13, 15 and the mounting device 17 with the X-ray detector 11 are located  
here in their outset position symmetrically to the base 9. In this position, the  
20 positioning device 1 has minimal bulk ~~and presents only insignificant~~ and allows  
machine operators or medical professionals hindrance to the access to easily  
accessibility to the patient support device table 5 to machine operators or medical  
professionals.

[0027] In a ~~further another~~ embodiment of the positioning device 1, the X-ray  
30 detector 11 is supportable on the arched arm 15 in ~~such a way that~~ the X-ray

~~detector 11 it can be moved in the radial direction relative to the arch and toward the patient table 5 in the drawing. This motion is illustrated in Fig. 2 which is represented by a vertical arrow. For this purpose, the mounting device 17, which that is supported movably in the direction of the arch in the arm 15 and, is~~  
5 ~~radially adjustable. The X-ray detector 11, which that is held by the mounting device 17, can as a result be brought closer to a patient located in the center of the arch. In this embodiment, shown, in which the positioning device 1 is located under the tabletop 5, an arrangement can accordingly be achieved in which the~~  
10 ~~X-ray detector 11 is can be brought from under toward the tabletop 5, and this is which is represented by dashed lines in the drawing Fig. 2. This arrangement is similar to that for of an X-ray machine in which the X-ray detector is attached immediately under the table 5 either fixedly or movably in the longitudinal direction and is exposed vertically from above, that is, Generally, this type of arrangement is a so-called a Bucky system. Because of the radial movability of~~  
15 ~~the X-ray detector 11, the positioning device 1 can therefore also be used as a Bucky system.~~

**[0028]** In Fig. 3, an X-ray machine 21 with a positioning device 1 is shown. The positioning device 1 has an arched arm 15 and a ~~further second~~ arched arm 13, ~~by way of which arms an~~ An X-ray detector 11 is supported as described  
20 ~~above in a base 9, displaceable on a circular arc. The X-ray detector 11 is supported in the arm 15 via a supporting arm 19 and a mounting device 17. The positioning device 1 is located below a patient-supportingsupport device, which that comprises a tabletop 5 supported on a table pedestal 7. No further details of the patient-supporting device are shown in the drawing.~~

**[0029]** Located above the patient-supportingsupport device is an X-ray source 23, which is supported in a ceiling-mounted tripod 25. The X-ray source 23 is movable in the vertical and horizontal directions, as indicated by corresponding  
25 ~~arrows. Moreover, the X-ray source 23 it is rotatable may rotate about a horizontal axis and about a vertical axis, which is also indicated by arrows. Because of the~~

three-dimensional movability of the X-ray source 23, virtually all arbitrary X-ray angles can be set.

[0030] The positioning device 1, because of its movability, ~~on the one hand~~ assures that the X-ray detector 11 can be oriented in such a way, ~~in that~~ adaptat  
5 ~~ion to~~ virtually all X-ray angles. ~~In other words, that it the X-ray detector is~~  
~~oriented both in the X-ray beam and vertically to the X-ray beam it. In particular,~~  
~~As shown by the arrows in Fig 3, the X-ray detector 11 is rotatable may rotate~~  
~~about a vertical axis, as is indicated in the drawing by an arrow. For this~~  
~~purpose, Accordingly, it the X-ray detector 11 is supported rotatably on the~~  
10 ~~supporting arm 19, or the supporting arm 19 is supported rotatably on the arm 15,~~  
~~or the arm 13 is rotatable in the base 9. The maximum settable angle of rotation~~  
~~depends on the construction, which is adapted to the particular use.~~

~~Advantageously, it~~ In one embodiment, the settable angle of rotation amounts to at  
least 20°. Because of the free movability of the X-ray source 23 and the X-ray  
15 ~~detector 11, virtually all~~ arbitrary radioscopy angles for examining a patient; ~~(not~~  
~~shown);~~ lying on the tabletop 5 can be attained.

[0031] In Fig. 4, an X-ray machine 21 with a positioning device 1, ~~and an X-~~  
ray source 23, and as well as a control unit 27 ~~are~~ is shown in perspective. The  
positioning device 1 has a base 9, ~~in which the~~ that has arched arms 13, 15, ~~and~~  
20 ~~The X-ray detector 11 are~~ is supported displaceably and movably on a mounting  
device 19. The mode of operation of the positioning device 1 corresponds to that  
described in the foregoing drawings.

[0032] The X-ray source 23 is supported three-dimensionally movably on a  
ceiling-mounted tripod 25 and likewise, as described above, is movable in the  
25 horizontal and vertical directions and is rotatable about a horizontal and a vertical  
axis.

[0033] The three-dimensional movability of the X-ray source 23 and of the X-  
ray detector 11 ~~make~~ makes it possible to set (adjust) ~~the most various~~ radioscopy  
directions. The X-ray detector 11, for making an X-ray image, is located in the X-

ray beam of the X-ray source 23 that is represented by dashed lines in the drawing, and vertically to it.

5        ~~As shown in Fig. 4, the X-ray machine 21 has a control unit 27, which is shown in the drawing without further details. The X-ray source 23 is connected to the control unit 27 via an electrical cord 29. As a result~~ Accordingly, both the generation of X-radiation and the motion of the X-ray source 23 in space can be controlled by the control unit 27. The positioning device 1 with the X-ray detector 11 is also connected to the control unit 27 via a cord 29. ~~As a result~~ Thus, the motion of the positioning device 1 can ~~also~~ be controlled by the control unit 27, and image data from the X-ray detector 11 can ~~furthermore~~ be transmitted.

10        ~~[0035] The control unit 27 has a control program, by means of which that controls the motion of the X-ray source 23 and of the positioning device 1 can be controlled automatically. In one version~~ embodiment, the control program is designed such that the X-ray source 23 can be oriented manually by a machine operator. From position detectors, (not shown), the control unit 27 receives information about the present position of the X-ray source 23 and triggers the positioning device 1 in such a way that the X-ray detector 11 follows along with the motions of the X-ray source 23. In a ~~further~~ another embodiment, the control program of the control unit 27 is designed ~~such that~~ so the X-ray detector 11 and the X-ray source 23 ~~are moved~~ move along a circular path, diametrically opposite ~~one another of each other~~, around a patient, (not shown), lying on the tabletop 5. X-ray image data, recorded in various X-ray beam directions along such a circular path, ~~can be~~ are processed to make three-dimensional images or images of slices of the body ~~to be~~ that is examined. The processing of the image data is done in a way similar to ~~how it is done in~~ computed tomography, or in the a way such that image data ~~is~~ are processed by means of a C-arm X-ray machines. The control unit 27 thus controls the X-ray source 23 and the positioning device 1 in such a way that the motion of a C-arm X-ray machine is simulated.

20        ~~[0036] As~~ Operating the X-ray detector 11 in ~~conjunction~~ combination with the positioning device 1 described above allows, a digital X-ray detector, ~~can~~

~~advantageously be used, such as a solid-state detector, to be used. As a~~  
~~result~~Accordingly, X-ray image data ~~are~~is available immediately after the images  
are made, ~~which. This~~ is especially advantageous in interventional medical  
applications.

5     **[0037]**     ~~Further~~Embodiments of the positioning device 1 may have only one  
or a plurality of arched arms, with a corresponding mode of operation. For  
example, ~~Other~~ versions of the X-ray machine 21 may ~~for instance~~ have a wall-  
mounted or floor-mounted tripod, instead of a ceiling-mounted tripod 25. A  
version in which the positioning device 1 is embodied such that instead of an X-  
10   ray detector it has an X-ray source, and in which the X-ray detector is instead  
located separately from the positioning device 1, is also possible.

## ABSTRACT OF THE DISCLOSURE

[0038] ~~The invention relates to a~~ positioning device (1) for an X-ray detector (11) or an X-ray source (23) is provided. The positioning device includes, comprising an arched arm (15), inside of which the X-ray detector (11) or the X-ray source (23) can be mounted in a manner that enables the detector or source to be displaced in the direction of the arch. The positioning device includes, and comprising a base (9), inside of which the arched arm (15) is mounted in a manner that enables the arched arm to be displaced in the direction of the arch. Either the X-ray detector (11) is mounted in the positioning device (1) and the X-ray source (23) is placed separately therefrom or, conversely, the X-ray source (23) is mounted in the positioning device (1) and the X-ray detector (11) is placed separately therefrom.